

Controlled-Release Microcapsules for Smart Coatings for Corrosion Applications

2006 Center Director's Discretionary Fund Project



Corrosion
Control

Corrosion is a serious problem that has enormous costs and serious safety implications. Localized corrosion, such as pitting, is very dangerous and can cause catastrophic failures. The NASA Corrosion Technology Laboratory at Kennedy Space Center is developing a smart coating based on pH-sensitive microcapsules for corrosion applications. These versatile microcapsules are designed to be incorporated into a smart coating and deliver their core content when corrosion starts. Corrosion indication was the first function incorporated into the microcapsules. Current efforts are focused on incorporating the corrosion inhibition function through the encapsulation of corrosion inhibitors into water core and oil core microcapsules. Scanning electron microscopy (SEM) images of encapsulated corrosion inhibitors are shown in Figure 1.

Different formulations and conditions have been used to achieve the desired microcapsule size and size distribution. Though a homogenous size distribution is normally preferred, different sizes might be required for different applications. For example, a size of about 20 to 40 μm is suitable for corrosion indication, whereas a smaller size might be better for inhibitor delivery. Figure 2 shows microcapsules of various sizes ranging from 2 to 100 μm .

A common concern about incorporating microcapsules into paint systems is that their interaction with paint constituents could lower the adhesive and protective properties of the paint. The effect of the microcapsules on several paint properties of interest was tested by incorporating microcapsules into four representative paint systems (acrylic, epoxy, polyurethane, and siloxane) and applying the paint to sandblasted carbon steel test panels ($6 \times 4 \text{ in}^2$). The test results showed that, in most cases, incorporating these microcapsules into the representative paint systems had no significant effect (more than 15 percent) on the paint adhesion properties. These results are shown in Figure 3.

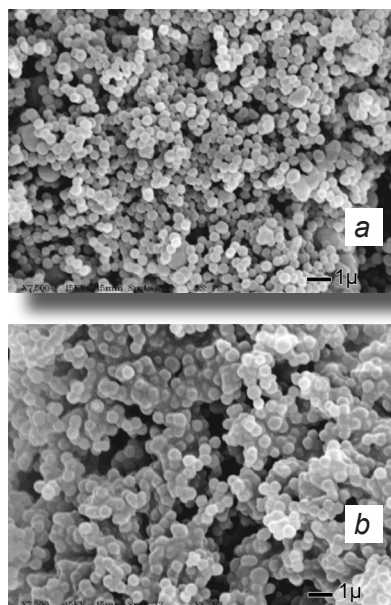


Figure 1. SEM images of dried microcapsules: (a) water core with corrosion inhibitor $\text{Ce}(\text{NO}_3)_3$ and (b) water core with corrosion inhibitor Na_2MoO_4 .

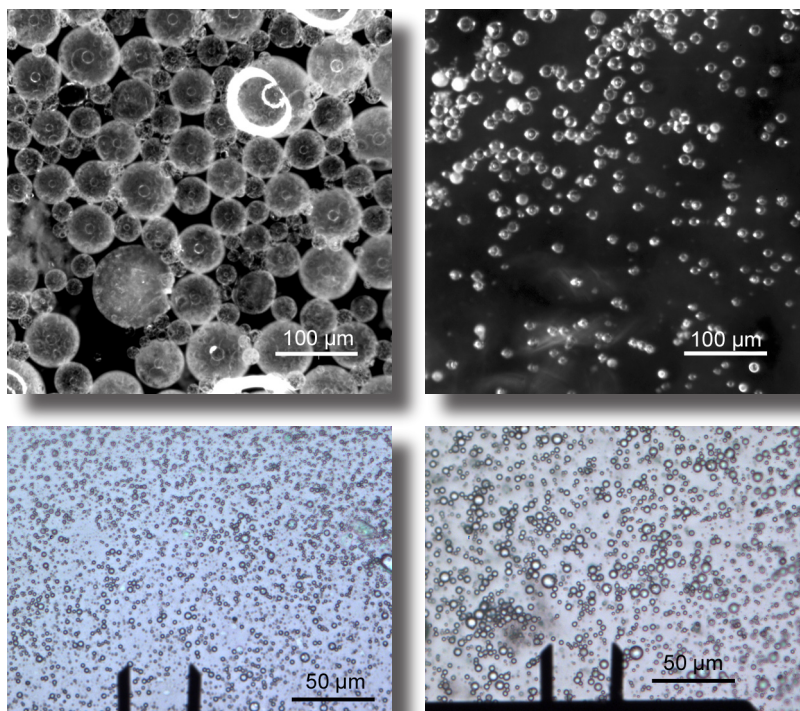


Figure 2. Microcapsules of various sizes.

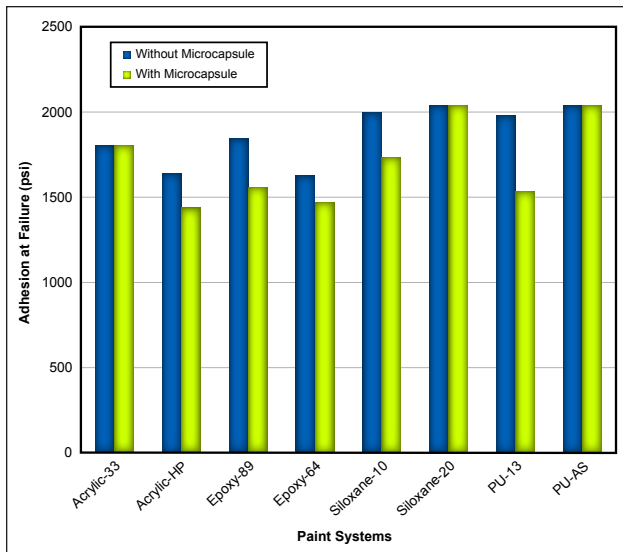


Figure 3. Adhesion test results.

A second concern is that the microcapsules might not survive the coating process, so the stability of the microcapsules in the coatings was examined by means of SEM. Figure 4 shows SEM images of well-dispersed microcapsules. The microcapsules appear to be intact and perfectly spherical, thus proving satisfactory survivability with no signs of rupturing.

A third concern is that the microcapsules might not keep the same functionality they exhibited in the colloid system or dried-powder form in dried paint. This concern was investigated through tests the pH sensitivity of the microcapsules in dry paint. Figure 5 shows the vivid color changes observed when the microcapsules in the dry paint were exposed to basic pH conditions.

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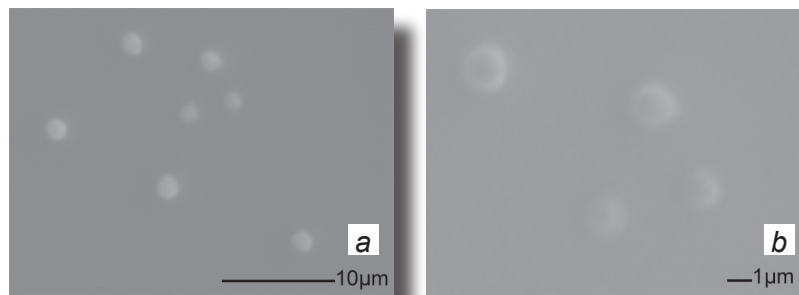


Figure 4. SEM images of epoxy coating with microcapsules captured at (a) 3,500× and (b) 7,500× magnification.

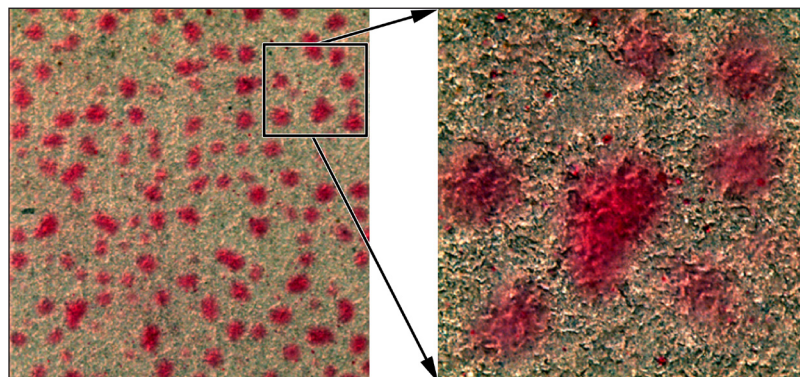


Figure 5. Color change observed when microcapsules in dried paint were exposed to basic pH conditions.